

EXPERIENCES WITH MICROIRRIGATION FOR AGRONOMIC CROPS

IN THE SOUTHEASTERN USA

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ABSTRACT

Microirrigation offers several advantages over sprinkler irrigation in humid areas, including ease of automation; lower water pressure and flow rate; improved management of water and nutrients; and easy seasonal start-up, especially for subsurface placement. Microirrigation system cost could be reduced and made more profitable for agronomic crops by using wider spacing and subsurface placement of microirrigation laterals. Results are reviewed from five experiments involving microirrigation of agronomic crops (corn, soybean, and cotton) and including 14 site-years of data. Agronomic crops can be effectively and efficiently irrigated in the southeastern Coastal Plain with microirrigation systems. In three experiments involving nine site-years of data, both normal (0.76 - 1.0 m) and wide (1.5 - 2.0 m) lateral spacings were used to irrigate corn and cotton; yields were equal except in one year when corn yield was reduced by about 10% for the wide spacing. With corn, there was no yield difference between surface and subsurface placement of laterals at the normal spacing (every row). Other data indicate that wider spacing of laterals in subsurface installations produces cotton lint yields similar to those for the same spacing in surface placements. Consequently, it appears that surface or subsurface placement of laterals at wider spacings (alternate furrow, 1.5 - 2.0 m) has significant potential for profitable irrigation of agronomic crops such as corn, cotton, and soybean in the southeastern USA.

Keywords: Lateral-placement, Trickle-irrigation, Lateral-spacing, Corn, Cotton, Soybean

INTRODUCTION

In humid areas, such as the Coastal Plain in the southeastern USA, seasonal rainfall is sometimes sufficient to satisfy evapotranspiration (ET) requirements. However, the combination of short drought periods (5-20 days) and low water storage capacity (about 5-10 days storage) of the coarse-textured soils often results in periods of yield-reducing plant water stress. Shallow crop rooting, often caused by compacted soil layers, further aggravates the problem. Periods of 5-20 days without rainfall occur during most growing seasons. The consequences of these drought periods depend upon crop, soil, timing, and the antecedent soil water conditions. Irrigation can alleviate these problems, but profitability of irrigation is extremely variable. Because irrigation is often not required at regular intervals or in all years, managers seldom plan for irrigation-related needs along with other farm operations. Consequently, irrigation systems in humid areas should be designed with low labor requirements (preferably automatic control), easy annual start-up/convenience, multiple-year life, and adequate capacity to sustain crops during drought.

Although sprinkler irrigation is most often used for agronomic crops, microirrigation offers several advantages—including low application rates, precise water placement, and low pressure requirements. When used in the conventional manner, the major disadvantage of microirrigation is high cost. This is partially caused by annual replacement and disposal of many system components. A microirrigation system that reduces the amount of material

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needed and uses materials for multiple seasons would reduce system cost. Possible solutions include wider lateral spacing and deeper placement (below tillage depth). Wider spacings were used on a coarse-textured soil in Arizona, where cotton yields were similar for laterals placed every row (1-m spacing) and every other row (2-m spacing) but were much lower for laterals placed every third row (3-m spacing) (French et al., 1985). Deeper placement of microirrigation tubing (0.2 - 0.3 m deep) allowed shallow tillage and cultivation for cotton (Tollefson, 1985), potato (Sammis, 1980), and fruits and vegetables (Bucks et al., 1981; Phene et al., 1987; Camp et al., 1993a) and obviated the need for annual removal/replacement of system components.

A possible microirrigation system for humid areas includes wider tube spacing (about 2 m), multiple-year life, and subsurface installation (below tillage zone) to reduce labor and material costs; however, the system should have the capacity to sustain a crop during short- to mid-term drought periods, possibly with limited yield reduction during severe drought. To investigate the feasibility of this irrigation system, results are reviewed from several experiments that used various microirrigation lateral placements both on the soil surface and subsurface.

MATERIALS AND METHODS

Five experiments were conducted over a 12-year period, 1980-92, using various microirrigation lateral spacings and placements relative to the crop row and/or soil surface for corn, soybean, or cotton. Experiments are described briefly, either individually or collectively if the same irrigation system was used. In all experiments, water was supplied from either a well or a municipal supply and was filtered via a 100-mesh cartridge filter, pressure was regulated at each plot manifold using a pressure regulating valve, and water flow was controlled via solenoids on a volume basis.

Corn Row Spacing (CRS)

Treatments in a corn experiment were two plant populations, two N side-dress rates, single rows or twin-row pairs with rows and row-pairs spaced about 1 m apart, and three water management regimes (two irrigation scheduling methods and rainfall only) during the 3-year period, 1980-82. The overall objective of the experiment was to identify the combination of cultural practices that would produce maximum corn grain yield in the southeastern Coastal Plain. Irrigation was provided using 380- μ m-thick double-wall (Bi-Wall[™]) microirrigation laterals spaced 0.5 m apart on the soil surface and equidistant from crop rows. Emitters were spaced 0.3 m apart along the lateral and delivered 4.3 L/h/m at 85 kPa pressure. New laterals were used each year. Additional details regarding this experiment were reported by Camp et al. (1985).

Soybean Row Spacing (SRS)

During 1980-81, soybean was grown in treatments consisting of four row spacings (0.36, 0.51, 0.76, and 1.02 m), two row orientations (N-S and E-W), two cultivars (Davis and Coker 338), and two water management regimes (rainfall only and irrigation). Irrigation was provided by 380- μ m-thick double-wall (Bi-Wall) microirrigation laterals installed on the soil surface at a spacing of 0.36 m. Emitters were spaced 0.3 m apart along the lateral and

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delivered 4.3 L/h/m at 85 kPa pressure, and new laterals were used each year. Irrigation applications were managed using tensiometer data, primarily at the 0.30-m soil depth.

Corn and Lateral Placement 1 (CLP1)

A microirrigation system was installed in the fall of 1984 to evaluate subsurface and surface placement of laterals, especially with respect to longevity of laterals used for several seasons. Three placements included laterals buried 0.3 m under each row (0.76-m spacing), laterals on the soil surface adjacent to each row (0.76-m spacing), and laterals on the surface in alternate furrows (1.52-m spacing). The first experiment (1985-87) also included two irrigation application modes, continuous or pulsed. Corn was grown in twin-row pairs spaced 0.24 m apart with each pair spaced 0.76 m apart. The microirrigation laterals (Drip-In) had in-line, labyrinth-type emitters spaced 0.61 m apart, each delivering 2.5 L/h at 115 kPa pressure. Additional details regarding this experiment were reported by Camp et al. (1989).

Corn and Lateral Placement 2 (CLP2)

Following the CLP1 experiment, a vegetable experiment was conducted on the site during 1988-89, and a second corn experiment was conducted during 1990-92. While the primary objective was to evaluate system longevity, the same lateral placements used in the first experiment were used in this experiment, and two irrigation scheduling methods were evaluated during 1990. Cultural practices were similar to those in the previous corn experiment.

Cotton and Lateral Spacing (CLS)

Cotton was grown during the period 1988-90 in an experiment that evaluated two microirrigation lateral spacings on the soil surface (adjacent to each row, 1.0 m apart, or in alternate furrows, 2.0 m apart) in relation to a rainfall-only treatment; three irrigation scheduling methods (GOSSYM/COMAX, water balance model, and tensiometer); and three cultivars (Coker 315, DPL 90, and PD 3). The microirrigation laterals (Netafim Dripperline) had in-line, turbulent-flow emitters spaced 0.6 m apart, each of which delivered 1.9 L/h at 100 kPa pressure. The same laterals were used for the 3-year period. Additional details regarding this experiment and the irrigation system were reported by Camp et al. (1993c).

RESULTS AND DISCUSSION

Seasonal rainfall and irrigation and agronomic crop yield for all experiments and all years are reported in Table 1. Although several crop management practices were included as treatments in the CRS and SRS experiments, yields for all variables except spacing are pooled because the microirrigation system was not varied in sub treatments. In both experiments, microirrigation was used to provide uniform surface irrigation in the canopy floor, not band irrigation near the row only, as in traditional microirrigation. There was substantial variation in seasonal rainfall years for CRS but not SRS. Irrigation amount varied between years for both CRS and SRS. Seasonal irrigation volume, however, was more closely related to seasonal ET for corn than for soybean. Corn grain yields for the irrigated, twin-row configuration were very high (11.50 - 14.06 Mg/ha) and were significantly greater than the rainfall-only treatment all three years (1980-82). Likewise, in the soybean experiment (SRS), mean yields were significantly greater for the irrigated treatment than for the rainfall-only treatment both years (1980-81). While yield differences sometimes resulted from other crop management variables, the greatest yield effect resulted from irrigation.

Seasonal rainfall and irrigation varied considerably during the two 3-year periods of the corn experiments (CLP1 and CLP2) with different microirrigation lateral placements (ER and AF),

Table 1. Seasonal rainfall, irrigation, and agronomic crop yield for microirrigation experiments conducted during the period 1980-1992 in the southeastern Coastal Plain of the USA.

Experiment/Crop*		Year	Treatment†	Rainfall	Irrigation	Yield	
						Rainfed	Irrigated
				----- mm -----		----- Mg/ha -----	
CRS	Corn	1980	Twin/T	297	448	5.28 c‡	14.06 a
CRS	Corn	1981	Twin/T	330	252	4.82 c	12.14 a
CRS	Corn	1982	Twin/T	485	155	10.49 b	11.50 a
SRS	Soybean	1980	Mean/T	461	382	1.51 b	3.10 a
SRS	Soybean	1981	Mean/T	453	202	2.57 b	3.01 a
CLP1	Corn	1985	ER/C	274	312	--	12.8 a
CLP1	Corn	1985	AF/C	274	331	--	13.1 a
CLP1	Corn	1986	ER/C	161	400	--	11.0 a
CLP1	Corn	1986	AF/C	161	387	--	9.8 b
CLP1	Corn	1987	ER/C	202	348	--	11.8 a
CLP1	Corn	1987	AF/C	202	373	--	11.4 a
CLP2	Corn	1990	ER/T	276	286	--	11.1 a
CLP2	Corn	1990	AF/T	276	286	--	10.2 a
CLP2	Corn	1991	ER/T	370	248	--	7.8 a
CLP2	Corn	1991	AF/T	370	248	--	7.8 a
CLP2	Corn	1992	ER/T	266	330	--	6.9 a
CLP2	Corn	1992	AF/T	266	330	--	6.4 a
CLS	Cotton	1988	ER/T	544	173	0.98 B	1.28 A
CLS	Cotton	1988	AF/T	544	175	0.98 B	1.16 A
CLS	Cotton	1989	ER/T	485	108	0.81 B	0.96 A
CLS	Cotton	1989	AF/T	485	96	0.81 B	0.83 B
CLS	Cotton	1990	ER/T	313	162	0.82 B	0.96 A
CLS	Cotton	1990	AF/T	313	127	0.82 B	0.86 B

* Experiment abbreviations are as follows: CRS = Corn Row Spacing; SRS = Soybean Row Spacing; CLP1 = Corn Lateral Placement 1; CLP2 = Corn Lateral Placement 2; and CLS = Cotton Lateral Spacing.

† Treatment abbreviations are as follows: AF = alternate furrow lateral placement; ER = every row lateral placement; T = irrigation scheduled by tensiometer; Twin = twin-row configuration; Mean = mean values for soybean cultivar, row spacing, and row orientation treatments; and C = continuous irrigation mode.

‡ Means followed by the same letter within row(s) or column(s) for an experiment-year combination are not significantly different at $P = 0.05$. In the CLS experiment, cotton lint yields are reported and capital letters are used because mean comparisons are valid only within a row (Irrigated vs. Rainfed).

and irrigation volume was generally related to seasonal rainfall volume. All values reported for the ER placement are means of values for surface and subsurface placement because seasonal irrigation volumes were equal or very similar in all years. Again, corn grain yield was high to very high, especially during the first 3-year period, and there was no significant yield difference between the two placements except in 1986. Seasonal rainfall in 1986 was

least of the six years because of a drought period that was one of the worst in the century. The drought was especially severe during the first half of the growing season, when corn plants were very small and had poorly developed root systems. Plant biomass and yield measurements indicate that corn in the row farthest from the irrigation lateral in the twin-row drill was shorter, had less biomass, had a lighter green color, and yielded less than rows closer to the irrigation source. There was a general decline in corn grain yield during the 6-year period, especially during the final 3-year period. This cannot be fully explained, but one reason for the lower yields in 1991 and 1992 was severe damage caused by birds. The damage appeared to be random and unrelated to treatment; consequently, comparisons among treatments should remain valid. There was no rainfall-only treatment in these experiments.

In the cotton experiment (CLS), seasonal rainfall varied considerably, decreasing each year of the 3-year period. Seasonal irrigation volumes were not closely related to seasonal rainfall volume during this experiment. A large range of irrigation volume was applied for the various irrigation scheduling methods during the 3-year period, but lint yield was not closely related to irrigation volume (all data not reported here). Using orthogonal contrasts, cotton lint yields (mean of three cultivars) were significantly greater for four of the six lateral placement-year combinations in the irrigation treatment than yields for the rainfall-only treatment. Using analysis of variance (SAS, 1990), the lateral placement effect was significant at $P = 0.09$. Because of inconsistent differences and a relatively low level ($P=0.09$) of statistical significance for the lateral placement treatment, we concluded that the wide and normal lateral spacings produced similar results.

All Experiments

Fourteen site-years of data from five different experiments using microirrigation systems indicated that they provided adequate irrigation for production of agronomic crops (corn, soybean, and cotton) in the southeastern U. S. Furthermore, nine site-years of data from three experiments indicated that wide lateral spacings in alternate furrows (1.5 - 2.0 m) produced yields comparable to those for normal lateral spacings (every row, 0.76 - 1.0 m) for these crops in this region. A wider lateral spacing should result in a savings of about 30% in initial irrigation system cost. Small yield reductions (10 to 20%) with wider lateral spacings during extreme drought can occur, but would be acceptable, especially when both reduced system cost and high humid-area rainfall probabilities are considered. In two experiments, with six site-years of data, corn yield for subsurface placement of laterals under every row was not significantly different from yield for laterals on the surface adjacent to every row. This indicates great potential for placing the irrigation lateral below the tillage zone where it can remain undisturbed for several years before replacement is required. This would significantly reduce system cost because of savings in annual material removal and replacement cost. Recent results indicate that subsurface systems can provide efficient, uniform irrigation for periods of at least 10 years in southeastern Coastal Plain soils without serious plugging (Camp et al., 1993b). The combination of wider lateral spacings and subsurface placement to allow greater longevity would produce additive material savings and increase profitability for these systems with agronomic crops. This combination is now being evaluated in an experiment with a cotton/peanut rotation. Preliminary results (3 years) indicate no difference in cotton lint yield between the normal (1 m) and wide (2 m) subsurface lateral placements (Camp et al., 1995).

SUMMARY AND CONCLUSIONS

An irrigation system for humid areas should have a low labor requirement (preferably automatic control), easy annual seasonal start-up, and the capacity to sustain crops during drought. Wider lateral spacings and use of laterals for multiple seasons (as in subsurface installations) provide additive savings in system cost and could make this technology profitable

for agronomic crops in the southeastern USA. Fourteen site-years of data from five experiments that evaluated microirrigation for agronomic crops (corn, cotton, soybean) indicated that this irrigation technology will provide acceptable irrigation for this region. Nine site-years of data from three experiments indicated that wider lateral spacings (1.5 -2.0 m) can provide acceptable irrigation most years for agronomic crops, and the yield reduction during extreme drought may be only 10% or less. This may be an acceptable risk for the humid area where rainfall probability is usually moderately high. In two experiments with corn, there was no difference in yield between surface and subsurface lateral placements when both had the same spacing. Other data indicate that wider lateral spacings in subsurface installations perform as well as normal spacings for cotton. From these data, it appears that surface or subsurface placement of laterals at wider spacings (alternate furrow, 1.5 - 2.0 m) offers significant potential for profitable irrigation of agronomic crops such as corn, cotton, and soybean in the southeastern USA. Subsurface lateral placement offers the potential to use the same material for at least 10 years without having to remove and install it each season, further reducing system cost.

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